



## TENDENCIES OF ORDER PICKING DEVELOPMENT AND INFLUENCE ON WAREHOUSE DESIGN

### TENDENCIJE U RAZVOJU KOMISIONIRANJA I UTICAJ NA OBLIKOVANJE SKLADIŠTA

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**Abstract:** Order picking is process that is realized in warehouses of unitize goods and includes all the activities that follows picking of demanded assortment of goods according to its kind and quantity in order to fulfill clients' demands exactly and on time. Performances of order picking process (productivity, reaction time, level of error rate, costs, etc.), in great measure depend on selected – used technology of storing, layout, order picking subsystems (usage of technology, ways on which the process is designed and controlled). Due to importance of order picking and constant efforts to increase its efficiency, there are different ways of reaching the aim. This paper shows main aspects of order picking and its development with special focus on usage of modern technologies for process handling.

**Key words:** Order picking, Warehouse, Logistics

**Apstrakt:** Komisioniranje označava proces koji se realizuje u skladištima komadne robe i uključuje sve aktivnosti koje prate izdvajanje traženog asortimana robe prema vrsti i količini u cilju ispunjenja korisničkih narudžbina tačno i na vreme. Performanse komisionog procesa (produktivnost, vreme odziva, nivo tačnosti-grešaka, troškovi i sl.) u velikoj meri zavise od izabrane – primenjene tehnologije skladištenja, layout-a, podsistema komisioniranja (primenjene tehnologije, načina na koji je sam proces oblikovan i upravljan). Zbog značaja komisioniranja i stalnih napora ka povećanju njegove efikasnosti, prisutni su različiti pravci ostvarivanja tog cilja. Ovaj rad daje pregled glavnih aspekata komisioniranja i njegovog razvoja sa posebnim osvrtom na primenu modernih tehnologija za upravljanje procesom.

**Ključne reči:** komisioniranje, skladište, logistika.

## 1 INTRODUCTION

Modern economy depends on efficiency of material flows, starting from raw materials flow, followed by flows in processes of finalization of product, to the final delivery of finished products to end users. These flows are realized through supply chains, which base components are production, transporting and warehouse systems. Each of these components must satisfy specific demands in order to realize total positive effects, and this paper is, due to special place and role in

## 1. UVOD

Moderna ekonomija zavisi od efikasnosti tokova materijala, počevši od tokova sirovina, preko tokova u procesima finalizacije proizvoda, pa sve do finalne isporuke gotovih proizvoda krajnjim korisnicima. Ovi tokovi se realizuju kroz lance snabdevanja, čije su osnovne komponente proizvodni, transportni i skladišni sistemi. Svaka od ovih komponenti mora da ispunji specifične zahteve da bi se ostvarili ukupni pozitivni efekti, a ovaj rad je, zbog posebnog mesta i uloge u

supply chains, dedicated to one of the processes that is realized in warehouses.

The main role of warehouses deals with buffering – collecting materials – inventories of raw materials, semi-products and products. Forming inventories by supply chain has the aim to fulfill benefits from place, time and quantity, with effort to make rationality of logistic activities and asked users' service level at the same time.

Processes in warehouse have multiple tasks and basic are: receiving of goods, processing and shipment. Special place in these tasks belongs to processing, and the process of order picking is its most complex shape. Order picking marks the special process that is realized in warehouses of unitized goods and includes all the activities that follows picking of asked assortment of good by its assortment and quantity in order to realize users' demands exactly and on time. Demands for order picking emerge in different roles in supply chains, linked to the production (assembly) or distribution.

In **production** we speak about warehouses of raw materials, semi-products and final products, when demands for order picking are based on orders from production equipment, and its roles are:

- modifying of raw materials to production needs,
- role of buffers (intermediate warehouse) of semi-product and
- modification of finished products to shipment demands or new production.

In **distribution**, order picking appears as place of transformation of basic shape of goods in warehouse to the shape/quantity type demanded by user (characterized mostly on type and quantity of goods), which means it process of preparing goods for shipment.

Although order picking is only one part of operations of handling of goods realized in warehouse, its importance is huge. Available analyzes from literature (Drury 1988; WERC 1999; Frazelle 2002.) shows that costs of order picking often exceed 50% of total operative costs of warehouse, while at the same time 60% of labor engagement in warehouse belong to these processes. Beside that, order picking is the

lancima snabdevanja, posvećen jednom od procesa koji se realizuje u skladištima.

Osnovna uloga skladišta odnosi se na puferisanje - nakupljanje materijala - zaliha sirovina, poluproizvoda i proizvoda. Formiranje zaliha duž lanca snabdevanja ima za cilj da se ostvare koristi od mesta, vremena i količine, a uz težnju da se jednovremeno ostvare racionalizacija logističkih aktivnosti i zahtevani nivo opsluge korisnika.

Procesi u skladištu obuhvataju više zadataka od kojih su osnovni: prijem robe, skladištenje, prerada i otprema. Posebno mesto u okviru ovih zadataka pripada preradi, pri čemu je proces komisioniranja njegov najkompleksniji oblik. Komisioniranje označava proces koji se realizuje u skladištima komadne robe i uključuje sve aktivnosti koje prate izdavanje traženog asortimana robe prema vrsti i količini u cilju ispunjenja korisničkih narudžbina tačno i na vreme. Zahtevi za komisioniranjem se pojavljuju u različitim kontekstima u lancima snabdevanja, vezano za proizvodnju (montažu) ili distribuciju.

U **proizvodnji** reč je o skladištima sirovina, poluproizvoda i gotovih proizvoda, kad se zahtevi za komisioniranjem robe odnose na narudžbine iz proizvodnog pogona, odnosno montaže, i njihova uloga se svodi na:

- prilagođavanja sirovina potrebama proizvodnje,
- ulogu pufera (međufaznog skladišta) poluproizvoda i
- prilagođavanja gotovih proizvoda zahtevima otpreme ili pak nove proizvodnje.

U **distribuciji**, komisioniranje se pojavljuje kao mesto transformacije pojavnog oblika robe na skladištu u pojavni oblik zahtevan od korisnika (okarakterisan pre svega vrstom i količinom robe), odnosno to je proces pripreme robe za otpremu.

Mada komisioniranje predstavlja samo deo operacija rukovanja robom izvršenog u skladištu, njegov značaj je veoma veliki. Dostupne analize iz literature (Drury 1988; WERC 1999; Frazelle 2002.) pokazuju da troškovi komisioniranja često premašuju 50% od ukupnih operativnih troškova skladišta, dok istovremeno 60% radnog angažovanja u skladištu pripada ovim procesima. Pored toga, komisioniranje predstavlja aktivnost

activity that mostly defines service quality that warehouse realize to users that in modern condition of trading has special importance. Present new philosophies and strategies in production and marketing sphere has the consequence in growth of goods assortment in warehouse, increase of demands for more frequent delivery of smaller ordered quantities followed by more requirement on more exact delivery (by contain and accuracy). All this additionally adding the handling of order picking process to be more complex, and the task to achieve the performances of this process on wanted level are heavier.

Performances of order picking process (productivity, reaction time, level of error rate, costs, etc) in great shape depends of chosen – used warehousing technology, layout, order picking subsystem (used technology, way the process is formed and controlled). Some of mentioned factors have already been the object of different levels and volume of researching in literature (Djurdjević, 2002).

Due to the importance of order picking and consistent efforts to increase its efficiency, there are different ways to achieve that aim, and this work deals with that. In order to cover this very complex topic in some comprehensive way the paper is organized through the following chapters:

- (i) introduction gives some wider review of the role of order picking in the warehousing,
- (ii) the chapter two provide the review of the most applied order picking subsystems together with their potential places of applications,
- (iii) the chapter three is dedicated to further tendencies in the development regarding this area, with the special attentions on the information systems,
- (iv) the conclusion summarized all present achievements in this area with particular critical attentions regarding their potential applications and perspectives.

## 2 ORDER PICKING SYSTEM

Order picking system, as subsystem in warehouse, usually represents functional unit with elements linked in the way that they provide execution of specific warehouse tasks<sup>1</sup>.

<sup>1</sup> According to that, he can from now on been shown as separated order picking system.

koja u velikoj meri definiše kvalitet usluge koje skladište pruža korisnicima, što u savremenim uslovima poslovanja ima posebnu težinu. Prisutne nove filosofije i strategije u proizvodnoj i marketing sferi za posledicu primene imaju širenje asortimana roba u skladištu, povećanje zahteva za frekventnijom isporukom manjih narudžbina uz sve izraženije insistiranje na većoj tačnosti isporuke (po sadržaju i vremenu). Sve ovo dodatno doprinosi da upravljanje procesom komisioniranja postane sve složenije, odnosno sve je teži zadatak da performanse ovog procesa budu na željenom nivou.

Performanse komisionog procesa (proizvodnost, vreme odziva, nivo tačnosti-grešaka, troškovi i sl.) u velikoj meri zavise od izabrane – primenjene tehnologije skladištenja, layout-a, podistema komisioniranja (primenjene tehnologije, načina na koji je sam proces oblikovan i upravljn). Neki od pomenutih faktora bili su već predmet različitog nivoa i obima istraživanja u literaturi (Djurdjević 2002).

Zbog značaja komisioniranja i stalnih napora ka povećanju njegove efikasnosti, prisutni su različiti pravci ostvarivanja tog cilja, čime se i bavi ovaj rad. Sa ciljem da se ukaže na glavne aspekte komisioniranja i njegovog razvoja, sam rad je strukturiran na sledeći način:

- (i) u uvodnom delu je dat detaljniji prikaza uloge komisioniranja u širem kontekstu,
- (ii) potom se u tački 2 daje pregled u praksi najzastupljenijih KS sa mestima primene,
- (iii) dalja analiza (tačka 3) je posvećena tendencijama razvoja u ovoj oblasti sa posebnim osvrtom na informacione sisteme,
- (iv) u zaključnom delu rada data je rekapitulacija ostvarenih dostignuća sa kritičkim osvrtom mogućnosti njihove primene i perspektive.

## 2. KOMISIONI SISTEM

Komisioni podsystem (KS) u okviru skladišta tipično predstavlja funkcionalno zaokruženu celinu sa elementima povezanim na takav način da omogućavaju izvršenje specifičnih skladišnih zadataka<sup>2</sup>.

<sup>2</sup> Shodno tome, on može nadalje da se posmatra kao poseban komisioni sistem (KS).

That are, above all, tasks of order picking that execute preparation of goods for shipment by forming units of shipment by demands of customer (customers' orders). The process of forming shipment unit includes activities (Figure 2.1) linked to: order picking, sorting, assembling different units of goods from existing warehouse assortment, typically with the need for change of type/quantity/shape of goods.

To su, pre svega, zadaci komisioniranja kojima se po zahtevima korisnika (korisničkim narudžbinama) obavlja priprema robe za otpremu formiranjem jedinica otpreme. Sam proces formiranja jedinice otpreme, u najopštijem, uključuje aktivnosti (slika 2.1) povezane sa: pripremom i vođenjem procesa komisioniranja; izdvajanja, sortiranja i spajanja različitih jedinica robe iz postojećeg skladišnog asortimana pri čemu se, po pravilu, pojavljuje potreba za promenom pojavnog oblika robe.

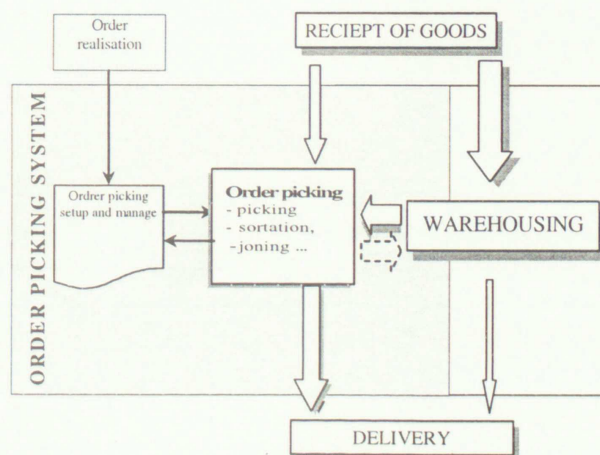


Figure 2.1 Order picking system  
slika 2.1 Komisioni sistem

Need for change of type/shape/quantity of goods is caused by the fact that in the warehouse – storage zone are, the content of storage unit, by its quantity mostly exceeds demanded quantity in customer's order. Differential type /shape/ quantity of goods on the delivery point looked on receiving point in warehouse or in storage area, generates increase of tasks complexity, therefore there is more complex structure of order picking systems. There is great number of solutions of order picking systems based on wide variety of types, sizes, functions of warehouses, as well as assortment of goods and user demands. For illustration, in Table 2.1 is given the view of usage possible solutions basic function of material flow in order picking system.

Having that in mind, order picking system can be classified in group of complex system with functionally united technological, organizational and managing parts. As already mentioned, there are different types of order picking systems characterized by different combinations of these basic parts. Theoretically, there are a huge numbers of potential combinations of those parts. According to the aim of this paper, the focus of this work is directed towards the smaller numbers of

Potreba za promenom pojavnog oblika robe uzrokovana je činjenicom da u skladištu – skladišnoj zoni, sadržaj skladišne jedinice, po količini najčešće prevazilazi zahtevanu količinu u korisničkoj narudžbini. Raznovrsnost pojavnih oblika robe na izlazu u odnosu na pojavni oblik robe na ulazu u skladište ili u skladišnoj zoni, generiše povećanje kompleksnosti zadataka, odakle proističe i usložnjavanje strukture KS. S obzirom na širok spektar tipova, veličina, funkcija skladišta, kao i asortimana roba i zahteva korisnika razvijen je veliki skup rešenja KS u okviru skladišta. Radi ilustracije, u tabeli 2.1 (Ten Hompel, M., and Thorsten S., 2007. ) dat je pregled primene mogućih rešenja za pojedine osnovne funkcije tokova materijala u procesu komisioniranja.

Imajući ovo u vidu, KS je moguće svrstati u grupu složenih sistema sa funkcionalnim jedinstvom tehnološkog, organizacionog i upravljačkog dela. Kako je već prethodno navedeno, u praksi se pojavljuju različiti tipovi komisionih sistema koje karakteriše različita kombinacija ovih osnovnih delova. Teoretski, broj kombinacija ovih osnovnih delova je izuzetno veliki, a shodno cilju ovog rada analiza

typical solutions that are frequently used in practice. Further, this paper gives the full review of all functional parts of the order picking as well as the review of problems that appear by selection of particular order picking system.

je usmerena na manji broj tipičnih rešenja najčešće primenjenih u praksi. U daljem tekstu dat je detaljniji prikaz funkcionalnih delova KS i problema koji se mogu sresti pri izboru KS.

Table 2.1 Basic functions of material flow in order picking processes

Tabela 2.1 Osnovne funkcije tokova materijala u procesu komisioniranja

Basic functions material flow	Possible implementations			
Moving goods to pick-up station	no movement	Movement		
		1-dimensional	2-dimensional	3-dimensional
		manual	mechanical	automatic
Picking	statical		dynamical	
	centralized		decentralized	
	sorted	partly sorted	unsorted	
Picker moves to pick-up station	no locomotion	Locomotion		
		1-dimensional	2-dimensional	3-dimensional
		manual	mechanical	automatic
Picker retrieves goods	manual	mechanical	automatic	
	single item		collective item	
Transport of pick-up unit to transfer station	no transport	Transport		
		picker		conveyor
		1-dimensional	2-dimensional	3-dimensional
		manual	mechanical	automatic
Transfer of pick-up unit	statical		dynamical	
	centralized		decentralized	
	sorted	partly sorted	unsorted	
Transport of picking unit to transfer station	no transport	Transport		
		picker		picker
		1-dimensional	2-dimensional	3-dimensional
		manual	mechanical	automatic
Transfer of picking unit	statical		dynamical	
	centralized		decentralized	
	sorted	partly sorted	unsorted	
Return of partial unit load	no return transport	Return to warehouse		Return to partial pallet warehouse
		1-dimensional	2-dimensional	3-dimensional
		manual	mechanical	automatic



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# КОСТОЛАЦ

## ТЕРМОЕЛЕКТРАНЕ И КОПОВИ



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## 2.1 Technological Aspect

There is great number of various types of order picking systems in usage, which are classified by using different criteria in literature (Frazelle 1990, Gudehus 1973, De Koster et al. 2006.), and according to need of concrete research. From technological aspect<sup>3</sup> (linked to movement of order picker in process of order picking) the most used is classification of order picking systems to:

- Man-to-good
- Good-to-man
- Automatic

*Man-to-goods* is system where order picker in realization of order picking tasks walks to warehouse locations with goods (most often in order picking area) to pick suitable number of goods units. Since the order picking activity is executed in working aisle, this class of order picking systems is also known as »*in-the-aisle*« system<sup>4</sup>. The movement, based on type of used technology in order picking systems can be: horizontal (on the floor), but also both horizontal and vertical (the examples are cherry picker and man-on-board in case of order picking in high racks when order picked on handling equipment can realize both types of movements).

Typical technological types of this order picking systems – typical technological in order to different types of order picking units can be shown by different combination of for warehouse and handling technologies, as shown in Table 2.1.1.

Basically, there can be differed: (i) systems where order picker picks goods from lower level rack (standard height up to 2m), moving along storage aisles on foot or on equipment (example: systems where good picking is realized on pallet jack or walkie forklift truck - Figure 2.1.1), and (ii) systems which have high-rack structures where order picker goes to location of good needed to be picked. Typical representatives of these systems are order picking systems based on cherry picker and *man-on board* system - Figure 2.1.2.

<sup>3</sup> Except this basic criterion, this classification contain criterions linked on level of automatisisation, as well as of the space where oprder pickin activites are realised.

<sup>4</sup> Based on de Kosteru i Le Ducu 80% of all order-picking systems in Western Europe.

## 2.1 Tehnološki aspekt

U praksi se sreće veliki broj različitih tipova KS, koji se u literaturi klasifikuju primenom različitih kriterijuma (Frazelle 1990, Gudehus 1973, De Koster et al. 2006.), a u skladu sa potrebom konkretnog istraživanja. Sa tehnološkog aspekta<sup>5</sup> (vezanog za kretanje komisionera u procesu komisioniranja), najopštija, a istovremeno i u literaturi najzastupljenija je podela KS na:

- Čovek - ka - teretu
- Teret - ka - čoveku
- Automatske

*Čovek-ka-teretu* je sistem gde komisioner u realizaciji komisionih zadataka odlazi do skladišnih lokacija sa robom (najčešće u komisionoj zoni) da bi izdvojio odgovarajući broj traženih jedinica robe. Pošto se komisiona aktivnost odvija u radnom prolazu, ova klasa KS se često u literaturi označava i kao »*in-the-aisle*« sistemi<sup>6</sup>. Pri tome kretanje, u zavisnosti od tipa KS primenjene tehnologije, može biti: horizontalno (po podu), ali istovremeno i horizontalno i vertikalno (primer su viljuškar za komisioniranje u vertikalnoj ravni (cherry picker) i regalski sлагаč (man-on-board) u slučaju komisioniranja u visokim regalima kada komisioner na manipulativnom sredstvu može istovremeno da realizuje obe vrste kretanja).

Tipični tehnološki oblici ovih komisionih sistema-tipične tehnologije u odnosu na različite pojave oblike komisionih jedinice mogu biti predstavljeni različitim kombinacijama tehnologija skladištenja i manipulisanja kako je to prikazano u Tabeli 2.1.1.

U osnovnoj varijanti mogu razlikovati: (i) sistemi u kojima komisioner izdvaja robu sa donjih nivoa skladišnih regala ili skladišnih polica (standardno do visine 2m) krećući se duž skladišnih prolaza pešice ili na sredstvu (na primer: sistemi gde se izdvajanje robe realizuje na paletna kolica ili viljuškar za horizontalno kretanje - slika 2.1.1), i (ii) sistemi koji podrazumevaju visokoregalske strukture gde komisioner na sredstvu odlazi do lokacija robe koju je potrebno izdvojiti. Tipični predstavnici ovih oblika su komisioni sistemi bazirani na viljuškaru za komisioniranje u vertikalnoj ravni i *man-on board* sistemi - slika 2.1.2.

<sup>5</sup> Pored ovog osnovnog kriterijuma, ova podela u sebi sadrži i kriterijume vezane za nivo automatizacije, kao i za prostor gde se obavlja komisiona aktivnost.

<sup>6</sup> Prema De Kosteru et al. 2006, 80% KS u zapadnoj Evropi pripada sistemima ovoga tipa.



Table 2.1.1 Subtypes of order picking systems in the aisle

Tabela 2.1.1 Podtipovi KS in the aisle

Warehouse technology	picking height	movement		
		walk	mechanized	
Pallet storage technology (pallet racks) and goods in smaller items (cartoons, totes, etc)	low	Walk and pick with order picking carts or order picking on the pallet on pallet jack	Order picking truck without lifting	
	high		Order picking lift truck for picking in vertical locations –cherry picker	Man-on board



Figure 2.1.1 Walkie fork lift truck  
slika 2.1.1 Komisioniranje paketa na paletu



Figure 2.1.2 man-on board system  
slika 2.1.2 man-on board sistem

Beside mentioned technological types of this system, in this group is also type *Pick-to belt* system, based on usage of conveyor. In this alternative, order picker picks units of good in his zone from shelf and put them on conveyor (Figure 2.1.3) or in handling unit (box or container) on conveyor that move it to the next zone-order pickers, where next operation is executed and like that till the fulfillment of the order. This technology of order picking systems is closely linked with usage of certain method of order picking, which will be detailed mentioned in the part of this paper related to organizational aspect of order picking system.

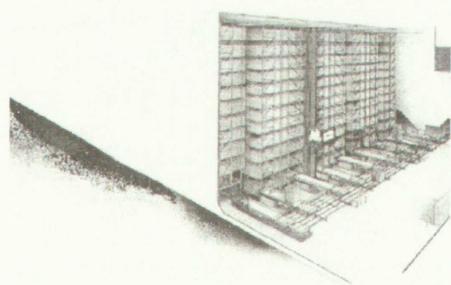
Pored navedenih tehnoloških oblika ovog sistema u ovu grupa spada i tip *Pick-to belt*, baziran na primeni transportera. U ovoj varijanti komisioner izdvaja jedinice robe u svojoj zoni iz police ili regala i stavlja ih na transporter (slika 2.1.3) ili u pomoćnu jedinicu (kutija ili kontener) na transporteru koji je odnosi do sledeće zone-komisionera gde se obavlja naredna operacija sve do konačnog ispunjenja komisione narudžbine. Ovaj tehnološki oblik KS usko je povezan sa primenom određenog metoda komisioniranja, o čemu će biti detaljnije reči u delu ovog rada posvećenog organizacionom aspektu KS.



Figure 2.1.3 Pick to belt system  
slika 2.1.3 Pick to belt sistem

**Goods-to-Man** is realized when materials to be picked is on time transferred from storage area and placed on picking point, where ordered items are picked. Rest of items (in storage unit) are returned to storage area. Using this method a lot of time, necessary for order picker walk is reduced, according previous order picking method (and is a high cost - up to 60% of order picking time spent - Tompkins at al. 2003, Rushton et al. 2000.); but picking time and waiting time to desired unit is greater. Generally, those systems involve higher mechanization level and are more realized in further alternatives:

- AS/RS (Automated Storage and Retrieval Systems) are automated solutions of high rack warehouses (Figure 2.1.4). The main characteristic is computer-controlled subsystems for storing and retrieval, which handle pallets. In order picking tasks, this system takes pallet with ordered material and transfer pallet to picking point, where order picker picks desired goods (type, quantity); rest of material on the pallet is moved back in storage (high rack) bin.



**Teret-ka-čovjeku** je sistem gde se roba za komisioniranje u datom trenutku transportuje iz zone skladištenja i postavlja na mesto za komisioniranje da bi se tamo izdvajala od strane komisionera. Višak robe (preostala količina iz sadržaja skladišne jedinice) posle izdvajanja se vraća u zonu skladištenja. Vreme potrebno za kretanja komisionera koje je predstavljalo značajnu stavku u vremenskoj strukturi komisionih zadataka prethodnog tipa (Tompkins at al. 2003, Rushton et al. 2000. iznosi i do 60% od ukupnog vremena, ) sada je izbegnuto, ali se povećava vreme izdvajanja i vreme čekanja na dopremu tražene robe do komisionog mesta. Generalno, ovi sistemi podrazumevaju uključenje većeg stepena mehanizacije. Oni su zastupljeni najčešće u sledećim varijantama:

- AS/RS (Automated Storage and Retrieval Systems) predstavlja automatizovanu verziju visoko regalnog skladišta (slika 2.1.4). Bitna karakteristika za ovu verziju je kompjuterski upravljani podsistem za uskladištenje i iskladištenje, koji rukuje sa paletnim jedinicama. U kontekstu komisioniranja primena ovog sistema podrazumeva izdvajanje palete iz skladišne zone - regala i njenu dopremu do komisionog mesta gde komisioner izdvaja potrebnu količinu jedinica robe, a preostala robe na paleti se vraća u skladišnu zonu.

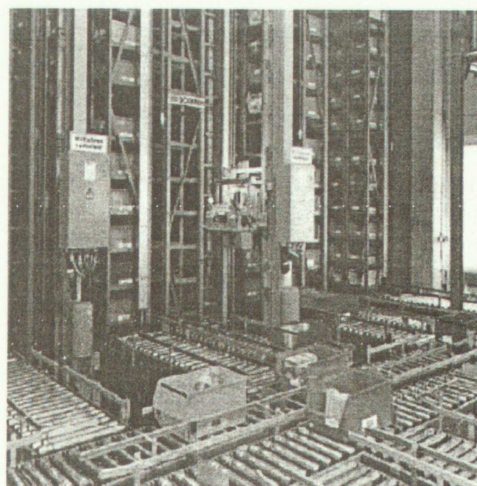


Figure 2.1.4 High rack warehouses  
slika 2.1.4 Izgled visokoregalnih skladišta

- Automated systems for smaller unit order picking are solutions of AS/RS systems, where handling unit is not pallet, yet smaller unit (e.g. mini load). Typical design is with order picking point on the end of the aisle, so this system is called as *end-of-aisle* order picking systems (Tompkins at al. 2003).

Automatizovani sistem za komisioniranje manjih jedinica, predstavlja verziju AS/RS sistema, s tom razlikom što jedinica rukovanja nije paleta, već manja jedinica (npr. mini load sistemi-posude). U tipičnim rešenjima stanica (mesto) za komisioniranje se nalazi na kraju prolaza, pa se ovi sistemi u literaturi često označavaju kao

Aiming to eliminate waiting time and increase order picker's productivity, each order picking point has two places for containers. According to requirement's characteristics, some other types of order picking areas are present (some are shown on Figure 2.1.5 based on MMH 1986.). Those system types enable high storage density and order picking low error rate. The high price of equipment and sophisticated maintain are main disadvantages of this technology.

*end-of-aisle* KS (Tompkins at al. 2003). U cilju eliminisanja čekanja i povećanja proizvodnosti u radu komisionera, svaka stanica za komisioniranje ima dva mesta za posude. U skladu sa karakteristikama zahteva pojavljuju se i drugi tehnološki oblici komisionih zona ( od tipičnih pokazani su na slici 2.1.5 prema MMH 1986). Ovaj tip sistema omogućava veliku gustinu skladištenja i zavidnu tačnost pri komisioniranju. Visoka cena opreme i sofisticirani zahtevi za održavanjem predstavljaju osnovne mane ove tehnologije.

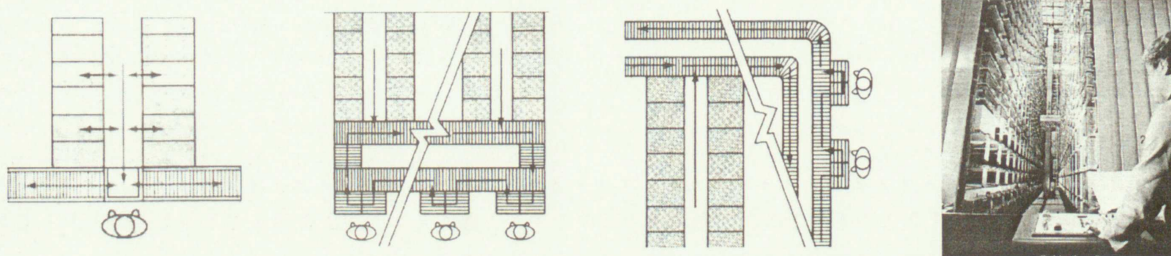


Figure 2.1.5 Alternative of motion paths and presentation of AS/RS for mini load units  
slika 2.1.5 Varijantna rešenja kretanja jedinica i izgled AS/RS za manje -mini load jedinice

Carousels are computer controlled warehouse equipment for storing and order picking of smaller units. Base difference of those systems is possibility that desired storage location is transferred to fixed location of order picker, instead he walks to good. Two technical solutions are present - as horizontal and vertical carousels (Figure 2.1.6), and vertical carousels are predominant for order picking processes. Base advantages are labor saving, ergonomic tailored workplace, high productivity, warehouse space saving, etc. The main disadvantage is high price compared with classic technologies and high replenishment tasks when material flow or turnover is intensive.

Karuseli predstavljaju kompjuterski kontrolisanu skladišnu opremu namenjenu za skladištenje i komisioniranje manjih jedinica. Bitna karakteristika ovih sistema u odnosu na konvencionalne (manuelne) je njihova mogućnost da rotacijom željena skladišna lokacija (roba) dođe u zahvat komisionera, koji se nalazi na fiksnom mestu, umesto da on ode do nje. Pojavljuju se u dve tehničke varijante - kao horizontalno i vertikalno optočni regali (slika 2.1.6), pri čemu horizontalni karuseli predstavljaju dominantni oblik za procese komisioniranja. Osnovne prednosti primene karusela su: ušteda u radu, ergonomska prilagođenost komisioneru, visoka proizvodnost, ušteda u skladišnom prostor i sl. Glavne mane su visoka cena u odnosu na konvencionalne tehnologije i veliki obim zahteva za popunjavanjem karusela robom kod visokog intenziteta obrta roba.

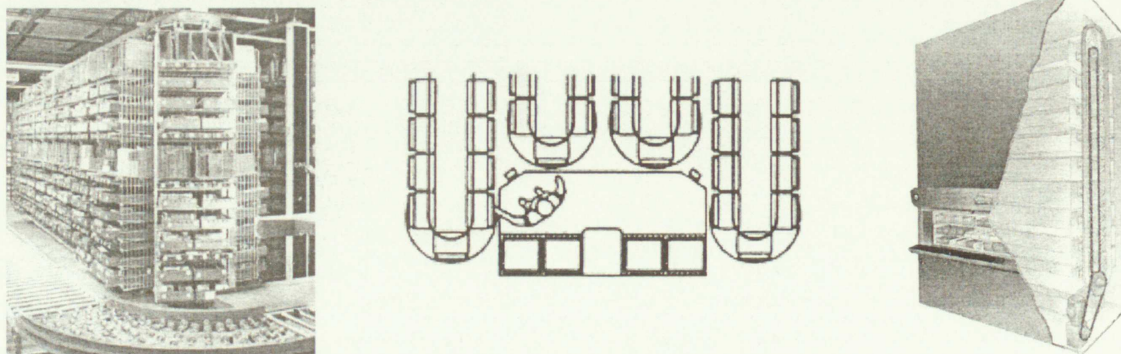
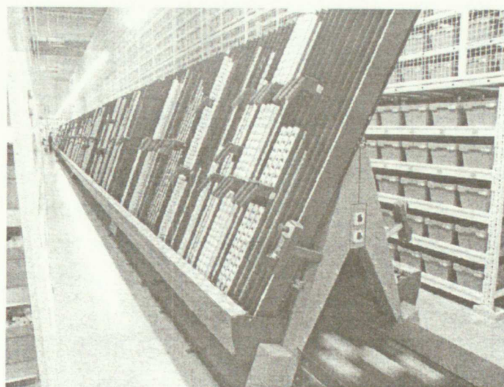


Figure 2.1.6 Horizontal and vertical carousels  
slika 2.1.6 Horizontalno i vertikalno optočni karuseli

- *Automated systems* enable unit picking without involving order picker and this is technology for picking small items. One design has mechanism that shifts units from storage location on belt conveyor (located along the aisle) that transport units to collecting point where they are sorted according client orders. Second design consists on "A" frame type, with inside located belt conveyor (Figure 2.1.7). Units (with electro or pneumatic mechanism) from frame on belt conveyor are automatically shifted. At the end of conveyer, units are collected in some container for order picking. Some light type indicates when stock level is lower of defined limit what generates task to worker to replenish missing quantity in the frame channel. Input of goods is from back side. Typically, this type is combined with flow-through racks (as reserve area), located on both sides of "A" frame. .

Effects of this system are: reducing storage space needed, high productivity, low error rate (microprocessor control this system, so error possibility is reduced significantly), low rate of good damage, high goods safety. But, this technology is limited on small units and predefined shape - e.g. cigarettes etc., low weight units, goods with fast throughput and when great number of orders has to be processed in short time, so those systems are present in some industries (pharmaceutical, cosmetic, tobacco ...).



- *Automatski sistemi* omogućavaju izdvajanje jedinice robe bez neposrednog učešća komisionera i predstavljaju tehnologiju za komisioniranje malih jedinica. U jednoj varijanti ove tehnologije mehanizam automatski potiskuje jedinice sa skladišne lokacije na trakasti transporter (postavljenog duž prolaza), a on ih transportuje do mesta gde se one nakupljaju i raspoređuju po narudžbinama. Druga varijanta ove grupe tehnologija bazirana je na nosačima u obliku slova "A" koja se sastoji od ramova sa robom iznad trakastog transportera (slika 2.1.7). Tražene jedinice robe se automatski (pogonjene električno ili pneumatski) izbacuju iz ramova na transporter. Izdvojene jedinice padaju u posudu za komisioniranje koja je postavljena na kraju trake. Svetlosni indikator pokazuje kada nivo robe u ramovima padne ispod zadate vrednosti što je znak radniku da popuni nedostajuću količinu u kanalu rama. Popuna robom ovih sistema je sa zadnje strane. Tipična rešenja ovog tipa komisionog sistema su bazirana na kombinaciji sa protočnim regalima (predstavljaju zonu rezervi), koji su locirani sa svake strane A okvira,.

Neke od karakteristika primene ove tehnologije su: smanjenje potrebnog skladišnog prostora, visoka produktivnost, smanjenje grešaka (pošto mikroprocesori nadgledaju ovaj sistem mogućnost greške je praktično neznatna), malo oštećenje robe, visoka bezbednost robe. Oblast racionalne primene je ograničena kod: jedinica robe malih dimenzija – određenog formata na primer: kutije cigareta i sl., lakih jedinica, "brzih" roba, kod situacija kada je veliki broj narudžbina potrebno obraditi u kratkom vremenu, tako da za sada nalaze širu primenu u farmaceutskoj, kozmetičkoj i industriji duvana.

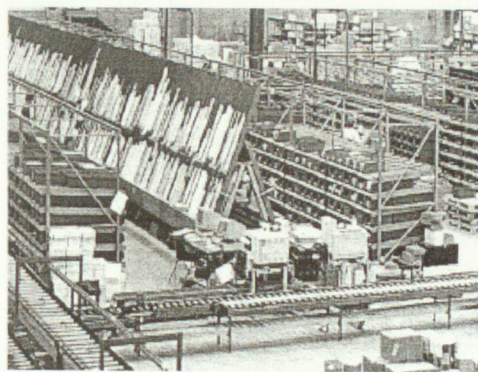


Figure 2.1.7 Automated handling systems for single small units (with "A" frame)  
slika 2.1.7 Automatski sistemi za rukovanje pojedinačnim manjim jedinicama

## 2.2 Organizational Aspect

Organizational aspect of order picking system depends of system's structure and processes management within the system, so he has important influence on his efficiency. Typically, organization differs on *structure organization* and on *organization of order picking process*

### 2.2.1 Structure organization

When structure organization or order picking area design is discussed, it concerns on different types of order picking area. There are two basic types:

- Order picking area integrated with storage area, and
- Order picking area as separate area

*Order picking area integrated physically with storage area*, should be in two basic types:

- ✓ Order picking area is completely "joined" in storage area, and
- ✓ Order picking area as a part of storage area.

Order picking area is completely "joined" in storage area - this form is used when clear differentiation of order picking system is not needed, and is acceptable, almost, when the rate of order picking tasks is low. Contrary, this form appliance should generate high operating cost resulting on long trips of order pickers

Order picking area as a part of storage area is an organizational form where defined part of warehouse - storing area is assigned to order picking activities. This organizational form could be present in few basic types:

- order picking area is located in lower levels of storage area - vertical separation,
- order picking area occupies part of paths in storage area - horizontal separation, and
- order picking area occupies particular paths in storage area.

## 2.2 Organizacioni aspekt

Organizacioni aspekt KS odnosi se na njegovu strukturu i upravljanje procesom u okviru sistema i kao takav ima veliki uticaj na njegovu efikasnost. Tipično, organizacija se deli na *organizaciju strukture* (tj. *aranažman komisione zone*) i na *organizaciju procesa komisioniranja*.

### 2.2.1 Organizacija strukture

Kada se govori o *organizaciji strukture* tj. *dizajnu* komisione zone, govori se o različitim tipovima komisione zone. U osnovi razlikuju se dva tipa:

- Komisiona zona je fizički integrisana sa skladištem rezervi, odnosno zonom rezervi, i
- Komisiona zona je zasebna celina.

*Komisiona zona fizički integrisana sa skladištem rezervi*, se pojavljuje u dva osnovna oblika kao:

- ✓ Komisiona zona (potpuno integrisana, "utopljena") u zonu rezervi, i
- ✓ Komisiona zona kao deo zone rezervi.

Komisiona zona potpuno "utopljena" u zonu rezervi, kao organizacioni oblik, se pojavljuje u situacijama kada ne postoji potreba za jasno diferenciranim KS, a posledica je najčešće malog broja zahteva za komisioniranjem. U suprotnom, primenu ovakve organizacione forme skladišnog prostora, bi po pravilu, pratili visoki troškovi rada, prouzrokovani velikim putevima komisionera.

Komisiona zona kao deo skladišta rezervi je organizacioni oblik koji podrazumeva da su određeni delovi skladišta - skladišne zone namenjeni za komisioniranje. Ovaj oblik organizacije pojavljuje se u nekoliko osnovnih vidova:

- Komisiona zona zauzima donje nivoe u skladišnoj zoni – vertikalno razdvajanje,
- Komisiona zona zauzima delove skladišnih prolaza u skladišnoj zoni – horizontalno razdvajanje, i
- Komisiona zona zauzima posebne skladišne prolaze u skladišnoj zoni.

a. Order picking area is located in lower levels of storage area - vertical separation

In this technology, order picking and warehouse activities are performed in the same aisle. Inventories in lower rack bins are locations for picking, and the upper bins are used for inventory keeping. Replenishment of lower level is realized from upper bins. Here, width of paths should be defined to enable simultaneously realization of warehouse and order picking activities. Avoiding interference while those processes are realized, it is necessary that they should be adequately terminated and synchronized. In lower level of pallet racks, according on present task's characteristics, appliance of other technologies is possible - rack for manual handling, flow - through or gravity racks, when higher picking density in order picking area.

1. Order picking area occupies parts of storage aisle in storage area – horizontal separation

Realization of warehouse and order picking activities is executed in the same storage aisles, so that parts of storage aisles can have different purpose – for example front parts are intended for order picking, and back parts for inventories zone. These organization spatially separates warehouse activities (order picking and store/retrieval) and eliminates their mutual interference and provides possibility for their realization at the same time. Usage of same mechanization tools for activities of embark/disembark in inventories zones and fulfillment of order picking area provides suitable usage of mechanization, but at the same time, there are important demands for storage space, which is mostly provided by width of order picking aisles (same as in reserve area).

2. Order picking area occupies separated storage aisles in storage area

In this solution, realization of order picking activities is executed in space independent from warehouse activities. The width of those aisles can be modified just by the demands of tools and activities

a) Komisiona zona zauzima donje nivoe u skladišnoj zoni – vertikalno razdvajanje

Kod ove tehnološke koncepcije realizacija komisionih i skladišnih aktivnosti se odvija u istom skladišnom prolazu. Zalihe u donjem nivou skladišnih regala su predviđene za komisioniranje, a nivoi iznad njih za skladištenje rezervi. Popuna robom donjih nivoa se obavlja iz zone rezervi. Širina ovakvih prolaza mora da bude dovoljno velika da omogući jednovremeno nesmetano odvijanje aktivnosti uskladištenja/iskladištenja i komisioniranja. Da bi se izbeglo njihovo ometanje pri jednovremenoj realizaciji potrebno je planiranje i usklađivanje ovih aktivnosti. U donjim nivoima paletnih regala, u skladu sa karakteristikama zahteva za komisioniranje, moguća je primena i drugih tehnologija: polica za ručno odlaganje, protočnih – gravitacionih regala čime se povećava gustina uzimanja u komisionoj zoni.

1. Komisiona zona zauzima delove skladišnih prolaza u skladišnoj zoni –horizontalno razdvajanje

Realizacija skladišnih i komisionih aktivnosti obavlja se u istim skladišnim prolazima, s tim što su delovi skladišnih prolaza – na primer njihov prednji deo namenjeni za komisioniranje, a njihov zadnji deo za zonu rezervi. Ovakva organizacija prostorno razdvaja skladišne aktivnosti (komisioniranje i uskladištenje/iskladištenje) i eliminiše njihovo međusobno ometanje i stvara pretpostavku za jednovremenost njihove realizacije. Primena istih sredstava mehanizacije za aktivnosti uskladištenja - iskladištenja u zoni rezervi i punjenja komisione zone omogućava pogodno korišćenje mehanizacije, ali istovremeno, kod ove organizacione forme, treba imati u vidu i značajne zahteve za skladišnim prostorom, čemu u velikoj meri doprinosi znatna širina komisionih prolaza (ista kao u zoni rezervi).

2. Komisiona zona zauzima posebne skladišne prolaze u skladišnoj zoni

U ovoj varijanti realizacija komisionih aktivnosti se odvija prostorno nezavisno od skladišnih aktivnosti. Širina ovih prolaza može da bude prilagođena samo zahtevima sredstava i aktivnosti koje se u

realized in them. This type of storage organization shows certain positive effects when compared to previous type. It provides more efficient realization of order picking and other warehouse activities, excludes the possibility of their mutual interference enabling their realization at the same time. The basic disadvantage of this type of order picking area are additional demands for space, which not only increases the price of system, but also in certain situations (usage of certain order picking methods) can increase movement when order picking.

*Order picking area as separate area* is an solution where with forming separate zone (in space and technological sense), concentration of order picking task on smaller space and/or use of special technologies efficient order picking realization is enabled. In this area practically all types of order picking technologies could be applied. However, this organizational approach, generate increased requirements on:

- warehousing space,
- additional investments in productive order picking technologies, and
- additional manipulations for fulfilling order picking area from reserve area.

Beside mentioned classification, based on organizational structure, also is interesting criterion where order-picking areas are classified on:

- statical and
- dynamical.

*Statical areas* are suitable for, in the long time period, stabile structure of goods present in order picking zone, but dynamically exchangeable good's structure needed for shorter time periods (daily even in hour etc). *Dynamic areas* have trend to be more and more present in warehouses in Europe due they enables increase of productivity. The problem of its suitable appliance in some situations, so the solution with combined approach (statical for A goods and dynamical for seasonal goods) could be useful in much tasks.

njima realizuju. Ovakav vid skladišne organizacije pokazuje izvesne pozitivne efekte u odnosu na prethodni oblik. On omogućava efikasniju realizaciju komisionih i drugih skladišnih aktivnosti, otklanjanjem mogućnosti njihovog međusobnog ometanja dopušta se jednovremenost njihove realizacije. Osnovnu manu ovog oblika komisione zone čine dodatni zahtevi za prostorom, što ne samo da povećava cenu samog sistema već, u izvesnim situacijama (primena određenih metoda komisioniranja) može da utiče i na povećanje kretanja pri komisioniranju.

*Komisiona zona kao zasebna celina* je organizacioni oblik gde se formiranjem posebne komisione zone (u prostornom i tehnološkom smislu) postiže koncentracija komisionog rada na manjem prostoru i/ili primenom specijalizovane tehnologije, a time omogućava efikasno izvršenje procesa komisioniranja. U ovoj zoni mogu da se pojave praktično svi predstavljeni tehnološki oblici KS. Ovakva skladišna organizacija, po pravilu generiše povećanje zahteva za:

- skladišnim prostorom,
- dodatnim investiranjem u "moćne" tehnologije za komisioniranje, i
- dodatnim zahtevima za punjenjem komisione zone iz zone rezervi.

Pored navedene *klasifikacije* na bazi organizacione strukture komisionih zona, interesantna je klasifikacija koja zone deli na:

- statičke i
- dinamičke.

*Statičke zone* podrazumevaju stabilnu strukturu roba zastupljenih u komisionoj zoni u dužem vremenskom periodu, a *dinamičke* izmenljivu strukturu kojom se zadovoljava tražnja za određenim robama u kraćim vremenskim periodima (danu ili čak satu i sl.). *Dinamičke zone* predstavljaju svojevrstan trend u evropskim skladištima iz razloga što doprinose povećanju produktivnosti komisioniranja. Postavlja se pitanje pogodnosti njihove primene u određenim situacijama. Možda kombinovani pristup, statički za robe A grupe, a dinamički za sezonske robe, predstavlja pogodno rešenje u za većinu situacija.

## 2.2.2 Organization of order picking process

Organization of order picking process concerns on defining their realization. Relevant factors, that are emphasized, are *customer's order* (with their characteristics) and selected *order-picking method*.

### *Customer's order*

Customer's order, as basic information source which generates order picking, is composed of few lines (rows), which determines goods to be picked. This order type typically is transformed in some form of *picking order*, accommodated to picking requirements. Order could be additionally fulfilled with information about goods to be picked: name, quantity, physical characteristics (dimensions, weight, package type etc.), location in storage, and some other information (cycle's number, storage zone, date, information of next/end users etc.). Distribution of lines on order is matched with picking process or some other requirements generated by handling tasks of order picker. This process assumes adequate software / hardware application, whereas it could be hard problem solving. Depending on selected order picking method, different alternatives of transformation of customer's order to picking order are possible.

Realisation of described processes (realizing customer's order) is very different in practice. The scope of different problems and approaches is shown by the analyze of typical order picking methods.

### *Order picking methods*

In literature focused on order-picking processes, especially on order picking methods as its organizational approach, as fundamental typically are present (Van den Berg 1999, Tompkins at al. 2003, De Koster et al. 2006.):

- sequential order picking,
- group (Batch) order picking and
- zone order picking.

*Sequential order picking* method is realized when one order picker realizes only one order on time, passing through warehouse and picking ordered

## 2.2.2 Organizacija procesa komisioniranja

Organizacija procesa komisioniranja se odnosi na definisanje načina realizacije samog procesa komisioniranja. Pri tome se, kao bitni faktori izdvajaju *korisnička narudžbina* sa svojim karakteristikama i izabrani *metod komisioniranja*

### *Korisnička narudžbina*

Korisnička narudžbina, kao osnovni nosač informacija kojom se inicira komisioniranje, sastoji se od određenog broja redova (linija), koji određuju robe koje treba uzeti. Ova narudžbina se po pravilu pretvara u neku formu *naloga za komisioniranje*, prilagođenu potrebama komisioniranja. Nalog se dopunjava specifičnim podacima o robi koju treba uzeti: naziv artikla, količina, fizičke karakteristike (dimenzija težina, način pakovanja i sl.), mesto robe i drugim podacima (broj ciklusa, skladišna zona, datum, informacije o korisnicima i sl.). Na narudžbini se sortiranje redova određuje prema redosledu uzimanja ili nekim drugim zahtevima koje nameće organizacija obrade prilagođena potrebama komisionera, tj. prilagođeno je izvršenju komisionog zadatka. Ovo podrazumeva primenu računara i odgovarajućeg softvera za rešavanje ovog, u nekim situacijama veoma komplikovanog zadatka. U zavisnosti od izabrane metode komisioniranja moguće su različite varijante pretvaranja korisničke narudžbine u nalog za komisioniranje (komisionu narudžbinu).

Realizacije opisanih zadataka (ispunjenja korisničke narudžbine) se različito realizuje u praksi. Spektar različitih situacija i pristupa je prikazan analizom karakterističnih *metoda komisioniranja*.

### *Metode komisioniranja*

U literaturi posvećenoj problemu komisioniranja, specijalno metodama komisioniranja – kao organizacionom pristupu realizacije procesa komisioniranja, kao osnovne metode najčešće se izdvajaju (Van den Berg 1999, Tompkins at al. 2003, De Koster et al. 2006.):

- Pojedinačno komisioniranje,
- Grupno (Beč) komisioniranje i
- Zonsko komisioniranje.

*Pojedinačno (Sekvencijalno) komisioniranje* je metoda kada jedan komisioner realizuje samo jednu narudžbinu – odnosno komisioni nalog;



items, which is then sent to warehousing or packing zone. The main advantage of this method, comprising low preparation costs, is integrity of client order. Disadvantage, at all, is that order picker spent has to pass a long trip in warehouse, so the needed traveling time per item is relatively high. In situations of orders with lot of lines, it is possible to create efficient order picking cycle in warehouse. Sometimes, if order is "inpatient", this is the most acceptable method instead the others.

*Group (Batch) order picking* assumes at first, collecting some customer's orders, and then defining order for order picking task. In this method, each order picker simultaneously is picking items due to orders for more customers. So, it is obvious that the main advantage of batch method is traveling time reduction per line (unit). However, using this method could result with lowering of order's integrity and generating additional manipulation tasks, as it is later sorting etc. That is the reason why benefits of time needed per line has to be compared with additional sort costs and possible errors when this method is used. General, this method is acceptable when huge number of orders (with less than five lines per order) is realized.

*Zone order picking* is method based on principle that each order picker has "its own" storage zone, where he is picking ordered items. Typically, it is used in warehouses where different shapes and technologies are present. The size of order picking zones should not be same, and the set of items to be picked in adequate zone is defined in adequate part in order. When picking of partial parts of orders in different zones is finished, it is necessary to integrate partial parts of picked items before order have to be delivered from warehouse. The main advantage of this method is reduced traveling time, as each order picker is focused on smaller storage zone, so time could be significantly shorter comparing with previous methods. Further advantage is that order picker becomes "familiar" with goods of "his" zone what enables more efficient work. But, those savings have to be compared with costs of sorting (if exists) and integration of items of each order having in mind possibility of errors when this method is used.

krećući se kroz skladište izdvaja traženi robni sadržaj nakon čega ga šalje do skladišnih zona pakovanja ili otpreme. Glavna prednost ove metode, uz male troškove pripreme, je da ne narušava integritet korisničke narudžbine. Osnovna mana je da pri obradi narudžbine komisioner prelazi veliki put kroz skladište, tako da je vreme puta po poziciji komisioniranja relativno veliko. Za velike narudžbine (one koje sadrže više od 10 linija) moguće je kreirati efikasnu komisionu turu u skladištu. Nekada interval strpljivosti za ispunjenje narudžbine ne dozvoljava primenu drugih metoda.

*Grupno (Beč) komisioniranje* podrazumeva prethodno nakupljanje određenog broja komisionih narudžbina, pa tek nakon toga formiranje naloga za komisioniranje. U ovakvom pristupu svaki od komisionera izdvaja robu za više narudžbina istovremeno. Jasno je da je glavna prednost beč metode u odnosu na prethodnu metodu, u redukcija vremena puta po poziciji (liniji) – komisioniranja. Međutim, u ovom slučaju prisutan je problem mogućeg gubljenja integriteta narudžbine i pojavi zahteva za dodatnim manipulacijama kao što je sortiranje i sl. Zbog toga, koristi od smanjenja vremena puta moraju da se uporede sa troškovima sortiranja i eventualnom pojavom grešaka u komisioniranju kod primene ovog metoda. Generalno ovaj metod može biti pogodan za obradu većeg broja manjih narudžbina (sa jednom do pet linija).

*Zonsko komisioniranje* je takav metod koji je baziran na pristupu da se svakom komisioneru dodeljuje specifični deo skladišnog područja odakle izdvaja traženu robu. Primenjuje se, tipično, u većim skladištima sa različitim skladišnim formama-tehnologijama. Veličina zone može biti promenljiva, a skup roba je definisan u delu naloga za komisioniranje u odgovarajućoj zoni. Nakon komisioniranja pojedinih delova komisionog naloga neophodno je objedinjavanje parcijalnih sadržaja narudžbine u jedinstveni sadržaj pre otpreme iz skladišta. Glavna prednost ove metode je u uštedi vremena puta, jer svaki komisioner pokriva manji deo skladišta tako da vreme puta po poziciji može biti znatno manje nego kod prethodne metode. Nadalje, prednost ove metode ogleda se i u činjenici da komisioner postaje »familijaran« sa robama u svojoj zoni što mu omogućava efikasniji rad. Međutim ovu uštedu u vremenu puta treba uporediti sa troškovima eventualnog sortiranja i objedinjavanja komisione narudžbine, kao i manjkavostima nastalim od mogućih grešaka nastalih primenom ove metode.

Combining those three methods, there are six, in practice real - acceptable order picking methods (Djurđević 2002). Structure of those combinations (methods) could be developed answering on next three questions:

- How many order pickers is engaged on one order realizing?
- How many orders are realized simultaneously?
- Is sorting of units needed and when is realized?

Figure 2.2.1 shows generating of those six typical order picking methods (M), according to activities that are involved. Each of those methods will be shortly described in following paragraphs.

Kombinovanjem ova tri osnovna metoda komisioniranja, može se izvesti šest različitih u praksi realno primenjivih metoda komisioniranja (Djurđević 2002). Struktura ovih tipova se ostvaruje kroz odgovore na sledeća tri pitanja:

- Koliko komisionera radi na obradi jedne narudžbine?
- Koliko narudžbina se obrađuje jedovremeno?
- Da li je potrebo sortiranje i kada se realizuje?

Na slici 2.2.1 je predstavljeno generisanje ovih šest tipičnih metoda komisioniranja (u zavisnosti od obuhvata aktivnosti) i svaki će biti kratko opisan.

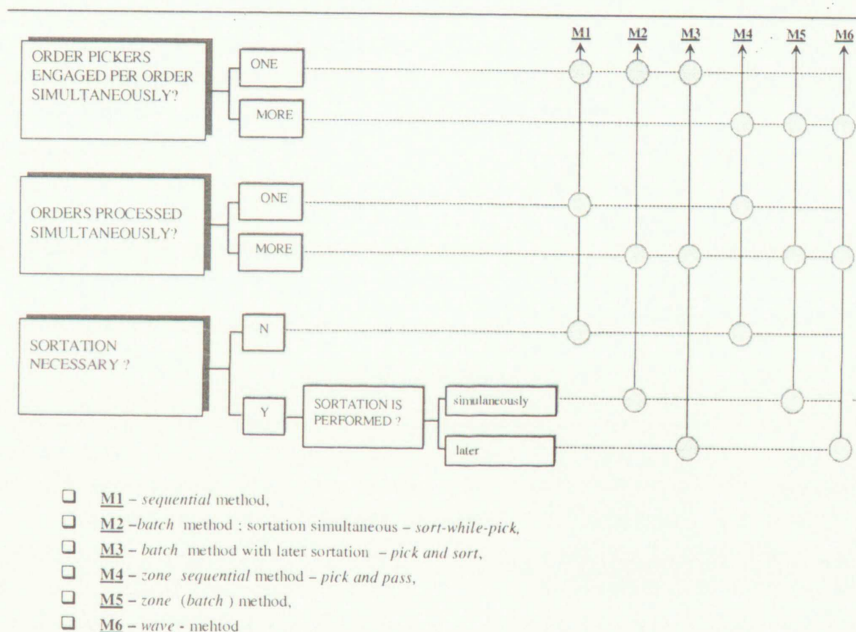


Figure 2.2.1 Generating of typical order picking methods  
slika 2.2.1 Generisanje tipičnih metoda komisioniranja

**M1** - is in practice one of the most order-picking methods applied. Here is assumed that each customer's order, introducing adequate data, is transformed in picking order and it is only realized in one order picker's passing through the warehouse. While passing (realized on foot or motorized handling equipment) order picker picks adequate items and moves the goods to delivering or packaging zone. Picking orders are typically in paper list where lines are sorted in manner according the location of items in

**MK1** - predstavlja u praksi najčešće primenjivani tip komisioniranja. On podrazumeva da se svaka prispela korisnička narudžbina, dopunjavanjem specifičnim podacima, prevodi u nalog za komisioniranje i samo on obrađuje u jednom prolasku kroz skladište. Komisioner krećući se kroz skladište (pešice ili na sredstvu unutrašnjeg transporta) izdvaja i odnosi/šalje robu do otpremne zone ili zone pakovanja. Nalozi za komisioniranje dati su, najčešće, u formi komisione liste gde je redosled pozicija uređen u skladu sa njihovim prostornim rasporedom u skladištu.

warehouse. This method is characterized by high punctuality, good control (one order picker is engaged in only one order realization so order's integrity is present) and low organizational cost. But, productivity of M1 is low (long trips while picking), so the method is limited on warehouses with lower assortment of goods and lower throughput, and where conditions allow longer time of passing all locations that are necessary in processing an order. Also, this method is acceptable when man-to goods is involved, especially when the ordered quantity matches with used order picker's handling unit.

**M2** - presents order-picking process when one order picker while picking cycle is realized, picks units for more orders. Idea is that the first customer's required items are collected, transformed in batch order list (with additional data, when needed) and transferred to order picker to be realized. In one trip (cycle) is realizing all clients orders from batch order list. Using more handling units while picking (pallets, boxes, totes...) or carts as shown on the figure, sorting could be performed simultaneously (where each handling units is used for separate customer's order). This method is often called *sort-while-pick*. The main advantage of this method is reduced traveling time per line. It should be noted that M2 is limited on lower number of orders that are included in batch and on lower volume orders.

**M3** - is very similar with previous method, specified that sorting is realized after all picks defined in batch order are completed (known as *pick-and-sort*). In this method sorting system or space for sorting is necessary to be present. Decision on involving this method is based on comparison of effect on traveling time per picked lines with requirements for later batch order in client's orders sorting.

**M4** - assumes that customer's orders are divided according storage zones where order picking of orders is realized. When order picker finishes orders partial picking (according items present in his zone), he transfer handling unit with picked items to the next zone where items stored and picked in that zone will be added. This process is repeating through zones until completing clients orders (method known as *pick and pass* method).

Ovaj metod karakteriše visoka tačnost, pregledan rad (s obzirom da jedan komisioner obrađuje samo jednu narudžbinu u toku komisijone ture, i da se ne narušava integritet narudžbine) i nizak organizacioni trošak. Efikasnost nije odlika MK1-tipa (velike putanje pri komisioniranju), tako da je oblast njegove racionalne primene ograničena pre svega na skladišta sa manjim asortimanom roba i niskim obrtom, i tamo gde uslovi dozvoljavaju duže vreme za obilazak lokacija robe od strane komisionera pri obradi narudžbine. Pored ovoga, ovaj metod može biti pogodan za KS čoveka-teretu, posebno u situacijama kada veličina narudžbine odgovara pomoćnoj transportno-manipulativnoj jedinici komisionera.

**MK2** - predstavlja takav pristup komisioniranju, koji podrazumeva da jedan komisioner za vreme jedne komisijone ture ispunjava više narudžbina. Suština je u tome da se korisničke narudžbine najpre prikupe, prevedu u beč komisijoni nalog (dopunjavanjem korisničkih narudžbina odgovarajućim podacima) i daju komisioneru na obradu. Komisioner na jednom putu kroz skladište ispunjava sve narudžbine koje su u sastavu beč naloga za komisioniranje koji mu je dodeljen. Korišćenjem više pomoćnih jedinica za komisioniranje (palete, posude, konteneri i sl.), ili pak specijalizovanih kolica komisioner može jednovremeno sa izdvajanjem robe da obavlja i njihovo sortiranje u ove pomoćne komisijone jedinice dodeljene svakoj od korisničkih narudžbina. Ovaj metod se često u anglosaksonskoj literaturi označava kao *sort-while-pick* metod. Glavna prednost u primeni ovog metoda ogleda se u smanjenje potrebnog vremena kretanja komisionera po izdvojenoj poziciji robe. Treba istaći da je primena ovog metoda ograničena na manji broj narudžbina uključenih u beč i na narudžbine manjeg volumena.

**MK3** - predstavlja u mnogome metod sličan prethodnom, stom razlikoma da se sortiranje realizuje nakon izdvajanje kompletnog sadržaja robe definisanog u beč nalogu (poznat je kao *pick-and-sort*). Ovo znači da primena ovog metoda komisioniranja podrazumeva i postojanje sistema za sortiranje ili prostora namenjenog za tu funkciju. Pri donošenju odluke o primeni ovog metoda treba uporediti efekte uštede u vremenu puta po izdvojenim pozicijama sa potrebom za naknadnim sortiranjem beč naloga u komisijone narudžbine.

**MK4** - podrazumeva podelu korisničke narudžbine prema skladišnim zonama u kojima se obavlja komisioniranje delova narudžbine. Kada komisioner u jednoj zoni obavi izdvajanje svih pripadajućih pozicija robe iz dela narudžbine, on prosledi pomoćnu komisijonu jedinicu do sledeće zone gde se dodaju sadržaji izdvojeni u toj zoni. Ovaj postupak se ponavlja redom kroz sve zone do konačnog kompletiranja korisničke narudžbine (literaturi je ovaj metod poznat kao *pick and pass* metod).

**M5** - is alternative of previous method, differs that in one zone more orders are processed simultaneously. When process is finished, as in previous method (here as batch order), customer's orders are prepared because the sorting is realized simultaneously by picking in storing - order picking zones.

**MK6** - is an alternative of zone order picking of clients orders - batch orders when is assumed that in all storage zones picking of all clients orders are realized simultaneously; when picking is realized, picked items are sorted in sorting system of warehouse. This method is adequate when different goods have to be stored in different warehouse technologies and short reaction time<sup>7</sup> of order picking is necessary. This is method with high productive, but high investments in sorting system are necessary.

### 2.3 MANAGING ASPECT

The base of managing aspect is defined by involved information system, which supports order-picking processes. It needs to collect, setup, process and presentation of all necessary information to order picking. For an order, high accuracy, completeness and on time realization are the key performances, and good information and communication system are essential for this goals. So, in this paper only managing segment concerned on adequate and right information presentation to order pickers guidance during realization of order picking tasks will be presented. This is, typically, one part of WMS (Warehouse Management System), and one software/hardware structure is shown on Figure 2.3.1.

Order picking process could be managed with different technologies. Long time present, also nowadays most present in practice technology is named on order in *paper* form. In "*paper*" system, man or computer are creating order picking list to order picker i paper form. Reading line by line on order, order picker is searching to right location, picks needed quantity, and notifies realized tasks or some changes generated on partially or complete inventory shortage of searched goods. In well-organized and managed

**MK5** - predstavlja varijantu prethodnog metoda, sa razlikom što se istovremeno u jednoj zoni obrađuje više narudžbina. Kao i u prethodnom slučaju u trenutku kada je obrađen (sada beč nalog), pripremljene su i korisničke narudžbine jer je sortiranje rađeno jednovremeno sa izdvajanjem robe u skladišnim – komisionim zonama

**MK6** - predstavlja varijantu zonskog komisioniranja zbira korisničkih narudžbina – beč naloga koja podrazumeva da se istovremeno u svim zonama skladišta obavlja izdvajanje pozicija koje su sastavni deo beč naloga, a zatima u sortimom sistemu obavi razdvajanje na korisničke narudžbine. Ovaj metod je pogodan u slučajevima kada postoji više različitih roba koje traže različite skladišne forme (tehnologije) i zahtevaju kratka reakciona<sup>8</sup> vremena. Ovo je visoko produktivana metoda ali traži značajnu investiciju za sortimi sistem.

### 2.3 UPRAVLJAČKI ASPEKT

Osnovu upravljačkog aspekta određuje primenjeni informacioni sistem koji podržava proces komisioniranja. Informacioni sistem treba da obezbedi prikupljanje, pripremu, obradu i prezentaciju svih informacija koje su neophodne za komisioniranje. Visoka tačnost, kompletnost i blagovremenost ispunjavanja narudžbina su ključne performanse, a dobar informacioni i komunikacioni sistem pretpostavka za dostizanje ovih ciljeva. Iz tog razloga, u ovom radu će detaljnije biti opisan samo segment upravljanja koji se odnosi na podesnu i tačnu prezentaciju informacija komisionerima kao pomoć u vođenju komisionera pri realizaciji komisionih zadataka. Ovo je inače jedan segment WMS-a (Warehouse Management System) - a izgled softversko/hardverske strukture je dat na slici 2.3.1.

Proces komisioniranja može biti upravljan na različite načine. Dugo dominantan, a i sada u najvećoj meri u praksi prisutan, je način zasnovan na primeni *papira*, odnosno komisione liste-naloga. U "*papirnom*" sistemu, čovek ili računar sastavljaju narudžbinu i kreiraju komisionu listu u papirnoj formi za komisionera. Komisioner sa nalogom – listom za komisioniranje, čitajući liniju po liniju teksta sa spiska, pronalazi traženu skladišnu lokaciju, izdvaja traženu količinu robe, evidentira izvršenu aktivnost ili notira promene nastale usled delimičnog ili potpunog nedostatka tražene robe.

<sup>7</sup> Time that elapses from order receipt to complete order delivery.

<sup>8</sup> Vreme koje protekne od prijema narudžbine do njene potpune otpreme.

warehouses, with experienced order pickers this technology is working correctly. Advantage of this system is relative low cost of introducing and use, but now days the scope of implementation is limited on tasks with low requirements on information flow and speed of order processing; as it is simple, the probability of errors in processes is high.

Nowadays, number of modern warehouses that use "paperless" technology increases<sup>9</sup>. Basically, in this technology all order picking activities are traced electronically, what reduces / eliminates possible errors related on goods recognition, location finding, data entry etc. The order in paper form is exchanged with electronic of data transfer (materials, number of units to be picked, picking location - address in storage and so on, with IR, RF communication etc.) to terminals that are present on every workplace - equipment. Working in this environment enables higher efficiency, lower error rate, on line actual information are present. Existing information in computer is transferred to order-picker - or any point where some activities is performed. Due that order picker have no paper, his hands are free and permanent tasks involved on reading, writing, etc are eliminated, so productivity is increasing more than 50% ([www.siemens-dematic.com](http://www.siemens-dematic.com)). In the same time, lowering errors with this technology is important because the system is guiding order picker to determined location and inform him about quantity need to be picked. High investment costs and high sensitivity of those systems (while breakdown of the system) are main disadvantages. Nowadays, two *paperless systems* are most present in practice:

- *Pick-to light* and
- *Real time manage systems*.

*Pick-to light manage system* uses display which is guiding order-picker to right location and shows right item quantity to be picked. This display could be installed on each rack, shelf; it could be useful on carousels, flow-through racks, AS/RS. More technical designs are present, and

<sup>9</sup> Inquiry realized in warehouses in USA, year 2000, result that 85% use computer in inventory control, 68% has computerized system for location assignment, while 33% use line code (source: The Journey to Warehouse Excellence, [www.tompkinsinc.com](http://www.tompkinsinc.com)).

U dobro organizovanim i upravljanim skladištima sa iskusnim komisionerima ovaj sistem funkcioniše korektno. Prednost ovog sistema je u relativno niskim troškovima njegovog uvođenja i primene, ali oblast njegove primene u sadašnjem trenutku je ograničena na situacije koje karakterišu niski zahtevi u pogledu brzine protoka informacija i obrade naloga. Pored na prvi pogled jednostavnih aktivnosti postoji mnogo mogućnosti za pojavu grešaka.

Danas već značajan broj modernih skladišta prelazi na savremenije<sup>10</sup> "bezpapirne" tehnologije. U suštini, ova tehnologija podrazumeva da se sve aktivnosti pri komisioniranju prate elektronski, što smanjuje/eliminise mogućnost pojave grešaka vezanih sa prepoznavanjem robe, pronalaženjem lokacije, unosom podataka, i sl. Papirna komisiona lista se zamenjuje elektronskim prenosom podataka (artikala, broja jedinica za izuzimanje, mesta uzimanja – adresa skladišne lokacije i sl.), posredstvom medijuma (infra crveno svetlo, radio talasi i sl.), ka terminalima koji se nalaze na svakom radnom mestu – uređaju. Rad u ovakvom okruženju omogućava veću efikasnost, niži nivo greške, prisustvo uvek aktuelnih informacija. Informacija koja već postoji u kompjuteru prosleđuje se komisioneru – odnosno do svake tačke gde se sprovodi neka aktivnost. Pošto komisioner ne nosi papir, njegove ruke su slobodne, a i neproduktivne aktivnosti vezane za čitanje, pisanje i sl. su eliminisane, čime produktivnost raste po nekim podacima i više od 50% ([www.siemens-dematic.com](http://www.siemens-dematic.com)). Pored ovoga, vrlo važna je i redukcija grešaka u radu, jer ovakav sistem vodi operatera – komisionera do tražene lokacije i upućuje ga – koju količinu robe da izdvoji. Visoki investicioni troškovi i visoka osetljivost ovih sistema za komisioniranje u slučaju pada sistema predstavlja njihove glavne mane. Po zastupljenosti primene izdvajaju se dva koncepta *bezpapirnog* sistema upravljanja:

- *Pick-to light* upravljanje i
- *Sistemi upravljanja u realnom vremenu*.

*Kod pick-to light sistema upravljanja* za vođenje komisionera koristi se displej za prikaz tačne lokacije uzimanja i tačne količinu za izdvajanje. Ovaj sistem može biti instaliran na svaki regal za palete ili policu za ručno odlaganje, a isto tako i kao pomoć pri komisioniranju iz karusela, protočnih regala i polica, AS/RS –a. Postoji više tehničkih rešenja ovog sistema.

<sup>10</sup> Rezultati analize sprovedene u skladištima u SAD krajem 2000-tih pokazuju da: 85 % skladišta prati stanje zaliha primenom računara, 68% ima kompjuterizovan sistem za dodeljivanje skladišnih lokacija, dok 33% skladišta koriste linijski kod. (The Journey to Warehouse Excellence, [www.tompkinsinc.com](http://www.tompkinsinc.com))

experiences confirm their rationale involving is when medium and fast moving goods of smaller size are picked, and it is used in processes where order picking of packed units are present. As it require adequate hardware for each picking location, the solution is useful where great picking tasks for an materials are present.

Iskustva govore da ovaj sistem oblast racionalne primene nalazi u situacijama rada sa srednje brzim i brzim robama čiji pojavni oblik karakterišu manje jedinice-komadi, dok se manje koristi kod komisioniranj paketnih jedinica. Pošto zahteva hardver za svaku komisionu lokaciju, lakše ga je opravdati tamo gde postoji veliki obim zahteva izdvajanja po robi



Control systems in real time uses RF-communication network to connect order picker and central computer in real time. On-board or hand terminals receive instructions and have possibility to various activities linked to communication with central computer (accepting, error correction, etc.). This system also uses system for automatic identification, which helps, in finding and accepting storage location, as units of picked products, when doing order picking activity. Usage of this system is suitable in order picking situation in bigger packages, while at single unit products – piece this system can be inadequate. This systems also have suitable program modules which provides (quick enough) minimization of order picker's route in real time. Usage of this system are most visible in area of cutting route time, error level etc.

Sistemi upravljanja u realnom vremenu podrazumevaju primenu RF- komunikacionih veza za povezivanje komisionera i centralnog računara u realnom vremenu. On-board ili ručni terminali primaju instrukcije i imaju mogućnost za obavljanje čitavog niza aktivnosti vezanih za komuniciranje sa centralnim računarom (potvrđivanje, korekciju grešaka i sl.). Ovaj sistem upravljanja podrazumeva i primenu sistema za automatsku identifikaciju koji u realizaciji komisione aktivnosti pomaže u pronalaženju i potvrđivanju skladišne lokacije, kao i jedinica izdvojene robe. Primena ovog sistema podesna je u situacijama komisioniranja roba u pojavnom obliku - paketa, dok kod pojedinačnih jedinica robe - komada ovaj sistem može da bude nezgrapnan. Ovi sistemi imaju i odgovarajuće programske module pomoću kojih je moguće (dovoljno brzo) minimizirati rutu komisionera u realnom vremenu. Koristi od primene ovog sistema su najočiglednije u oblasti skraćanja vremena puta, tačnosti obrade narudžbina i sl.



Special solution of those systems are based on speech recognition (*pick-to-voice*), where computer transforms electronic data in spoken words, when order-picker use that words to adequate manage a goods. In opposite direction, order-picker's words (confirmation of activity, shortage of goods etc) are transformed in the

Poseban oblik ovih sistema predstavljaju sistemi zasnovani na govoru *pick-to-voice*, kod kojih kompjuter transformiše elektronske podatke u glasovnu komandu, na osnovu koje komisioner vrši određene manipulacije sa robom. U drugom smeru, softver glasovnu poruku od komisionera (potvrda aktivnosti, nedostatak robe i dr.) transformiše u odgovarajući elektronski oblik za

form that is acceptable to computer. Advantage is that order-picker's hands are free of secondary activities and is focused on picking operations - he does not need to follow information on the screen - communication (where machine is as a man). This solution reduces error level and order-picker's productivity increases. Disadvantage is in obstacles of speech recognition (different accents, sex, level of language knowledge etc.) as well as refusing computer's directives.

kompjuter. Prednost se ogleda u oslobađanju ruku komisionera od sporednih aktivnosti i usredsređenje samo na aktivnosti uzimanja - izdvajanja robe i u činjenici da komisioner ne mora vizuelno da prati informacije npr. na monitoru, već je omogućena komunikacija sa mašinom kao sa čovekom. Ovaj sistem deluje u pravcu smanjenja nivoa grešaka pri radu i u pravcu povećanja produktivnosti komisionera. Mana je u nesavršenosti ovih sistema posebno u raspoznavanju glasa (razni akcenti, pol, nivo znanja jezika i dr.) kao i moguće neprihvatanje zadatih naredbi.

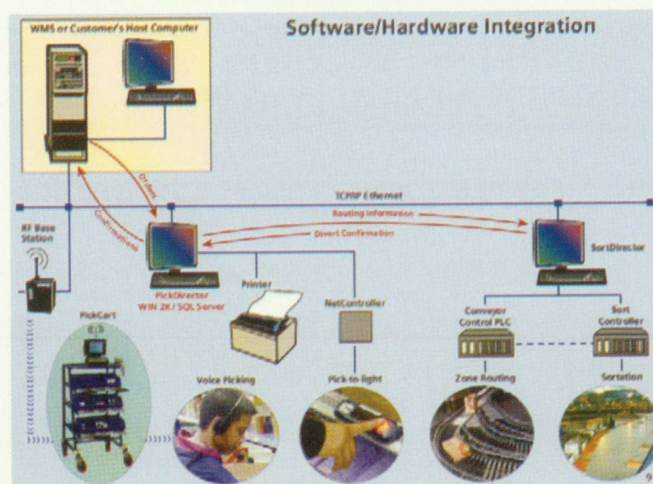


Figure 2.3.1 Hardware and software integration in order picking processes  
slika 2.3.1 Prikaz jedne integracije hardvera i softvera u procesima komisioniranja  
([www.siemens-dematic.com](http://www.siemens-dematic.com))

## 2.4 SELECTION PROBLEM OF ORDER PICKING SYSTEM

In the text above the different order picking possibilities are shown, concerning technology, organization and managing aspects. Having that in mind, selection of adequate order-picking system is a complex task which has to respect, anyway, following factors: (Djurđević 2002):

- Characteristics of a system that is designed,
- Order's characteristics and
- Characteristics of goods

## 2.4 PROBLEM IZBORA KS

U prethodnom delu rada dat je pregled različitih mogućnosti komisioniranja sa aspekta tehnologije, organizacije i upravljanja. Sam proces izbora odgovarajućeg KS, imajući u vidu izloženo, predstavlja kompleksan zadatak i on neizostavno mora da uvaži sledeće faktore (Djurđević 2002):

- Karakteristike sistema koji se projektuje,
- Karakteristike narudžbina, i
- Karakteristike robe

*Characteristics of a system that is designed* - the information about status, e.g. place and role of the system in broader scope and interaction with other (sub)systems are shown. Here are information about higher system involved, as well as information about type and number of users, way of supply, service level required, constrains (economical, environment protection requirements ...) etc.

*Order's characteristics* - include information about number of orders, line number/order, order's performing time limitations, and so on. Those characteristics usually have great influence on order-picking system technological solution.

*Characteristics of goods* - include information about type of goods, number of items, size, weight and other relevant characteristics (temperature, sensitivity on mechanical influence, danger, etc.); they are important on material handling/warehouse solution selection. For example, some characteristics are limitation for involving some technologies so, in some cases that can results wit increasing of the whole system costs.

1. Respecting those factors and involving adequate analyze (based on available data, at first about goods and orders) in system design process, it's possible to reduce huge number of possible solutions to be reduced on acceptable level. Also, some recommendations in this task are present - Figure 2.4.1 ([www.siemens-dematic.com](http://www.siemens-dematic.com)) where combinations of factors, that have influence on solution of order-picking system, are shown.

*Karakteristike sistema koji se projektuje* - daju informacije o statusu, odnosno mestu i ulozi sistema u širem kontekstu i njegove interakcije sa drugim sistemima. One sadrže i informacije o strateškim ciljevima nadređenog sistema, a takođe i informacije o tipu i broju korisnika, načinu snabdevanja, zahtevanom servis stepenu, ograničenjima (ekonomskim, zahtevima okruženja i dr.) i sl.

*Karakteristike narudžbina* - sadrže informacije o: broju narudžbina, njihovoj veličini (na primer: broju linija po narudžbinama), intervalu strpljivosti za njihovo ispunjenje i sl. Ove karakteristike po pravilu značajno utiču na tehnološko rešenje KS.

*Karakteristike robe* - sadrže informacije o: vrsti robe, broju jedinica robe, veličini jedinica robe, težini i drugim bitnim svojstvima (temperatura, lomljivost, stepen opasnosti i sl.). One utiču na izbor tehnologije skladištenja i rukovanja. Tako, na primer, neke od karakteristika deluju kao ograničavajući faktor na mogućnost primene određenih tehnologija, što može u izvesnim slučajevima da utiče i na uvećanje ukupnih troškova celog sistema.

1. Uzimanje ovih faktora u obzir i sprovođenjem određenih analiza (na bazi raspoloživih podataka pre svega o robi i narudžbinama) u procesu projektovanja sistema moguće je veliki broj potencijalno primenljivih varijanti svesti na razuman broj. Takođe, mogu se naći i određene preporuke u ovoj oblast - slika 2.4.1 ([www.siemens-dematic.com](http://www.siemens-dematic.com)) na kojoj su date kombinacije vrednosti faktora koje utiču na izbor KS.

		Lines Picked Per Person Per Hour												
		0	100	200	300	400	500	600	700	800	900	1000	1100	1200
Movement Category	A													Dispensers
	A & B				Light directed picking									
	A & B				Case pick - print & apply									
	A & B				Case pick label									
	B & C				Carousels & AS/RS									
	B & C				Voice									
	B & C				RF carts									
	C				RF picking									
	C				Paper									
			0	100	200	300	400	500	600	700	800	900	1000	1100
		Rock and shelving			Carton flow and pallet flow									

Key  
 A = Fast Movers  
 B = Medium Movers  
 C = Slow Movers

Figure 2.4.1 Recommendations on technology of order-picking system selection  
 Slika 2.4.1 Preporuka pri izboru tehnologije komisioniranja



### 3 TENDENCIES IN ORDER PICKING DEVELOPMENT

Beside all the efforts for more usage of mechanization and automatization for substitution and relieving human work, man as order picker will not be excluded from this task for a decent time. Many activities in order picking are possible to be automatized (data flow, movement of products and order picker), and they are used in numerous systems. Selection - picking of products in order picking process is especially difficult activity on that view. It is especially significant in situations where products of different size, shape, weights are handled – when manual handling still has no alternative. The new solutions which should enable total automatic order picking are inflexible due to demand for standardizations of order picking's object, so the profitability of their usage is very limited. It is similar situation with usage of robots as order picker. Robot needs great number of data from environment, making high demands for sensors. Their role should be to provide necessary information from environment, which would be handled by proper equipment. Beside development of intelligent sensors, where central place are problems of handling with pictures processing and object recognition, the development of new techniques in area of picking, positioning, guiding, where intensive researches are expected. In manual order-picking, order picker sees shape, geometry, size, way of picking of order picking unit, while robot must provide those information by sensors or by exact data of order picking object.

The important question in robot usage is the question of choice of picking device, when it is necessary to take look not only on geometry of handling object, but also on its weight, size etc. So, although it is possible to replace order picker by a machine in many activities, in central order picking activity of item picking, man and his hands are still the most perfect and the most efficient «tool».

It is possible that optimal solution on current level of development is in usage of mechanization and automatization in working area where it reduces worker's heavy physical intension, but with mentioned disadvantages. From that reason, possibilities of improvements are searched in implementation of ergonomic

### 3 TENDENCIJE U RAZVOJU KOMISIONIRANJA

Pored svih nastojanja za širom primenom mehanizacije i automatizacije za zamenu i rasterećenje ljudskog rada, čovek kao komisioner u dogledno vreme neće biti potisnut iz ove oblasti. Mnoge aktivnosti u procesu komisioniranja moguće je automatizovati (npr. prenos informacija, kretanje robe i komisionera) i one se primenjuju u brojnim sistemima. Izdvajanja - uzimanja robe u procesu komisioniranja predstavlja posebno nezgodnu aktivnost u ovom pogledu. Posebno je to izraženo u situacijama kada se rukuje sa robom različite veličine, oblika, težine i dr., - kada manuelno rukovanje još uvek nema alternativu. Nova rešenja koja bi trebalo da u potpunosti omoguće automatsko komisioniranje su zbog zahteva za standardizacijom objekta komisioniranja neefleksibilna i njihovo uvođenje generiše značajne troškove, pa je rentabilnosti njihove primene veoma ograničena. Slična je situacija i sa primenom robota kao komisionera. Robot zahteva veliki broj informacija iz okruženja, postavljajući na taj način visoke zahteve za sensorima. Njihova uloga bi se sastojala u obezbeđenju potrebnih informacija iz okruženja, a koje bi dalje obrađivali odgovarajući uređaji. Pored razvoja inteligentnih senzora, gde centralno mesto trenutno zauzimaju problemi obrade slike i raspoznavanje oblika, neophodan je i razvoj novih tehnika u oblasti zahvata, pozicioniranja, upravljanja gde se očekuju intenzivna istraživanja. Kod manualnog komisioniranja, komisioner vidi oblik, geometriju, površinu, način zahvata objekta komisioniranja, dok robot te informacije mora da obezbedi preko senzora ili preko egzaktnih podataka o objektu komisioniranja.

Značajno pitanje u primeni robota predstavlja pitanje izbora zahvatnog organa, pri čemu se mora voditi računa ne samo o geometriji objekta rukovanja već o njegovoj težini, površini i sl. Dakle, iako je u mnogim aktivnostima moguće komisionera zameniti nekim uređajem, u centralnoj komisionoj aktivnosti izdvajanja - izuzimanja robe, čovek i njegove ruke su još uvek najsavršenije i najefikasnije "sredstvo".

Verovatno da se optimalno rešenje na sadašnjem stepenu razvoja nalazi u primeni mehanizacije i automatizacije u oblastima rada gde ona oslobađa radnika od teškog fizičkog naprezanja, ali uz pomenute nepovoljnosti. Iz tog razloga, mogućnosti unapređenja se istražuju u primeni ergonomskih principa u projektovanju radnih

principle when projecting working places, which means usage of dynamic systems and modern technology for data relay and handling. Due to its importance and present tendencies of their development, these two aspects are shown more detailed in this work.

### *Usage of ergonomic principles*

In order to provide order picker's most efficient way to assign asked units of products (with maximum efficiency), it is necessary for them to be in the zone of most suitable reach of order picker – the *golden zone*. That's the zone in vertical pace, defined by the lines made in the height of waist and shoulder of order picker. It is clear that all products cannot be located in this zone, but one must insist that there should be heavier products, products with the biggest ratio of trade and/or the highest level of intensity of picking and storage. Systems based on «cargo-to-man» principle fulfill this condition / product for order picking is in the ergonomically most suitable zone – the golden zone. With elimination of order picker's movement, this facility makes the main advantage of usage of order-picking systems based on this principle, with all positive effects that follow (production, less stress – illness and injuries, etc.). Various solutions could be found that even more respect ergonomic principle, of which some are shown on Figure 3.1.

mesta tj. primeni dinamičkih sistema, i u korišćenju moderne tehnologije za prenos i obradu informacija. Zbog svog značaja i prisutnih tendencija u okviru njihovog razvoja ova dva aspekta su u ovom radu detaljnije predstavljena.

### *Primena ergonomskih principa*

Da bi komisioner mogao da na efikasan način izdvaja tražene jedinice robe (ostvarujući maksimalan učinak), potrebno je da one budu locirane u zoni najpogodnijeg zahvata komisionera – *zlatna zona*. To je zona u vertikalnoj ravni definisana linijama povučenim u visini struka i ramena komisionera. Jasno je da sve robe ne mogu da budu locirane u okviru ove zone, ali treba nastojati da tu budu teže robe, robe sa najvećim koeficijentom obrta i/ili najvećim intenzitetom zahvatanja i odlaganja. Sistemi zasnovani na principu "teret-ka-čoveku" ispunjavaju ovaj uslov - roba za komisioniranje pojavljuje se u ovoj ergonomski najpogodnijoj zoni - zlatnoj zoni. Uz eliminaciju kretanja komisionera ova pogodnost predstavlja osnovnu prednost primene KS zasnovanih na ovom principu, sa svim pozitivnim efektima koji iz toga proističu (produkcija, manje naprezanje-obolenja i povrede, i dr.). Može se sresti niz različitih rešenja koja još u većoj meri respektuju ergonomski princip (primena određenih tehničkih rešenja regala, uređenje radnih stanica i dr.) od kojih su neka predstavljena na slici 3.1.

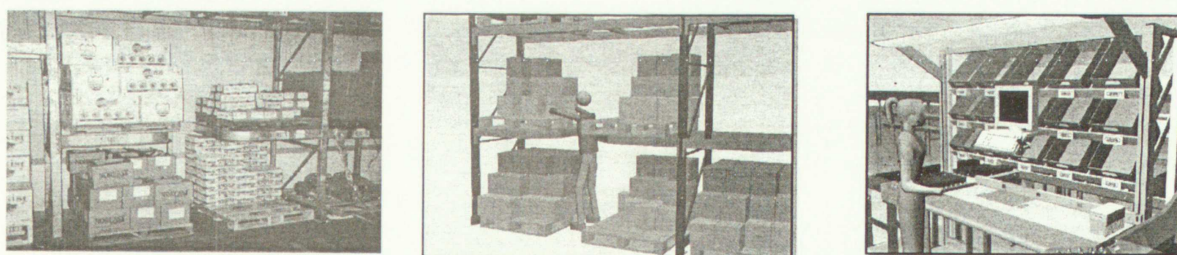


Figure 3.1 Some solutions for improving order picker's working conditions  
slika 3.1 Neka rešenja za poboljšanje uslova rada komisionera

### *Technologies for data transfer and handling*

One of the tendencies in warehouse, which will grow in importance and continue its development, deals with paperless information systems. There are many facilities provided by them: (Bode, W., and Rüdiger, W.P., 2007):

### *Tehnologije za prenos i obradu informacija*

Jedna od tendencija u skladištu koja će u budućnosti dobiti na značaju i nastaviti dalji razvoj odnosi se na bezpapirne informacione sisteme. Njima se ostvaruje čitav niz pogodnosti (Bode, W., and Rüdiger, W.P., 2007):

- Elimination of paper possessing, no writing jobs
- Reduction of the search times/orientation times
- Hands free for reaching (an exception are "handhelds")
- Reduction of wrong articles and wrong quantities leading to a reduction in staff costs for inspection and returns
- Optimization of the picking routes
- Possibility to treat rush orders with priority
- Updated stock quantities through interactive order picking
- Support of continuous stocktaking
- Reduced safety stocks due to monitored stock levels
- Link of the order picker in the replenishment chain
- Possibility to record times and performance data
- Reduction of training times for new staff.
- eliminacija obrade papira, nema, nema pisanja
- redukuje se vreme traženja/orijentacije
- ruke su slobodne za manipulativne aktivnosti (sem kod primene ručnih uređaja)
- redukovanje izuzimanja pogrešnih artikala i količina rezultuje smanjenjem troškova personala za kontrole i povratne tokove
- optimizacija ruta komisioniranja
- mogućnost obrade hitnih narudžbina sa prioritetom
- ažuriranje zaliha kroz interaktivno komisioniranje
- podrška kontinentalnoj kontroli zaliha
- redikovane sigurnosne zalihe zbog kontrole nivoa zaliha
- veza komisioniranja u lancu popunjavanja
- mogućnost memorisanja podataka o vremenu i aktivnostima
- redukovanje vremena obuke novog personala

In following table is shown the insight on usage of technologies in warehouse systems of different development level.

U narednoj tabeli je dat pregled (Peter Backe 2007) primene tehnologija u skladišnim sistemima različitog nivoa razvijenosti.

Laggards	Industry average	Best in class
Paper pick lists	RF Bar-code scanning	RF Bar-code scanning, supplemented with technology, e.g.: <ul style="list-style-type: none"> <li>• Pick-to-light,</li> <li>• Pick-to-Voice.</li> </ul>

On following Figures is shown the effect on productivity and accuracy, respectively, when introducing pick-to-voice in comparison to other existing paper and RF technologies in one American ([www.tompkinsinc.com](http://www.tompkinsinc.com)).

Na slikama u nastavku dat je pregled efekata u pogledu produktivnosti i tačnosti, respektivno, kod uvođenja tehnologije pick-to-voice u odnosu na papirne i RF tehnologiju u jednoj američkoj kompaniji (prema [www.tompkinsinc.com](http://www.tompkinsinc.com)).

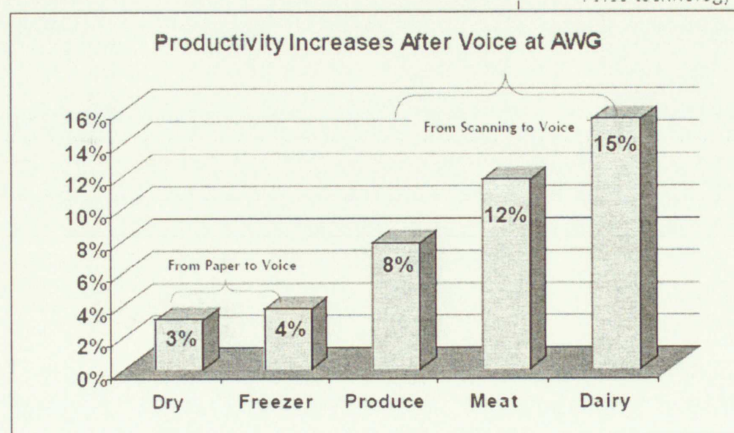


Figure 3.2. Picking Productivity Improvements after Voice Technology Implementation at AWG Kansas City.

slika 3.2. Ostvarena poboljšanja po uvođenju Voice Tehnologije kod AWG Kansas City.

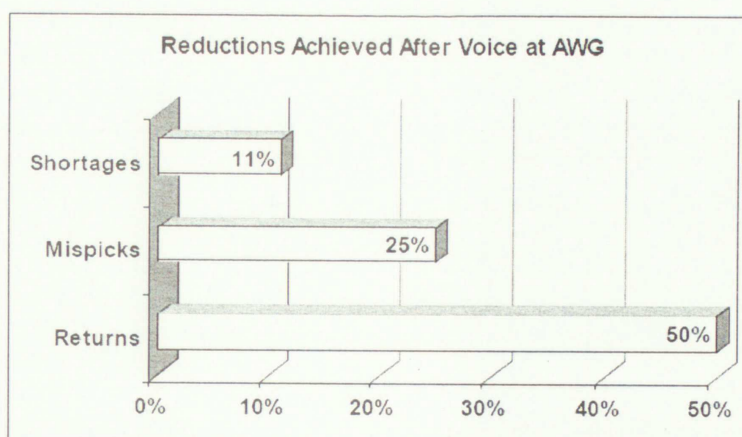


Figure 3.3. Reductions after Voice Technology Implementation at AWG Kansas City.  
slika 3.3. Smanjenja ostvarena po uvođenju Voice tehnologije kod AWG Kansas City

Often, like in other technological ways in warehouse, usage of hybrid solutions – combined technologies is the correct answer on question of choice of optimal technology type. The skill is about to determine valid combination, which means to determine which demands and situations makes that certain solutions are exposed as optimal. In following table ([www.hkplanet.net/mhc/2005](http://www.hkplanet.net/mhc/2005)) is the recapitulation of “paperless” technologies with relevant characteristics on typical usage and performances which can be helpful when decisions making.

Često, kako je to slučaj i sa drugim tehnološkim oblicima u skladištu, primena hibridnih rešenja - kombinovanih tehnologija predstavlja pravi odgovor na pitanje izbora tipa tehnologije. Veština se svodi na određivanje podesne kombinacije, odnosno koji zahtevi i situacije opredeljuju da se pojedina rešenja izdvoje kao optimalna. U tabeli ([www.hkplanet.net/mhc/2005](http://www.hkplanet.net/mhc/2005)) u nastavku data je recapitulacija “bezpapirnih” tehnologija sa relevantnim karakteristikama u pogledu tipične primene i performansi koja može da posluži kao pomoć pri donošenju odluka izbora.

	RF Scanning	Pick-to-Light	Voice Technology
Optimal Applications	<ul style="list-style-type: none"> <li>Picking in Low Density Areas</li> <li>For Data Gathering Needs</li> <li>Other Functions – forklift, etc.</li> </ul>	<ul style="list-style-type: none"> <li>Picking in High Density Areas</li> <li>Split Case</li> <li>Retail - Put to light</li> </ul>	<ul style="list-style-type: none"> <li>Picking Full &amp; Split Case</li> <li>Picking in Coolers/Freezers</li> <li>Picking Heavy Products</li> <li>Other Functions – forklift, etc.</li> </ul>
Software Included?	<ul style="list-style-type: none"> <li>No</li> </ul>	<ul style="list-style-type: none"> <li>Yes – For Directed Picking</li> </ul>	<ul style="list-style-type: none"> <li>Yes – Directed Operations</li> </ul>
Accuracy: Gross Error Rate	<ul style="list-style-type: none"> <li>5 errors per 1,000</li> </ul>	<ul style="list-style-type: none"> <li>3 errors per 1,000</li> </ul>	<ul style="list-style-type: none"> <li>0.2 to 2 errors per 1,000</li> </ul>
Pick Productivity	<ul style="list-style-type: none"> <li>50 – 250 lines/hour</li> </ul>	<ul style="list-style-type: none"> <li>100 -350+ lines/hour</li> </ul>	<ul style="list-style-type: none"> <li>100 – 300 lines/hour</li> </ul>
CapEx Model	<ul style="list-style-type: none"> <li>Per Site &amp; Concurrent Operator</li> </ul>	<ul style="list-style-type: none"> <li>Per pick location</li> </ul>	<ul style="list-style-type: none"> <li>Per Site &amp; Concurrent Operator</li> </ul>
Pros	<ul style="list-style-type: none"> <li>Good for Data Capture</li> <li>Flexible for Growth</li> </ul>	<ul style="list-style-type: none"> <li>Highest Productivity</li> </ul>	<ul style="list-style-type: none"> <li>Highest Accuracy</li> <li>Eyes-Free, Hands-Free</li> <li>Flexible for Growth</li> </ul>
Cons	<ul style="list-style-type: none"> <li>Requires Eyes &amp; Hands</li> <li>Lower Productivity</li> </ul>	<ul style="list-style-type: none"> <li>Zoning may cause throughput constraints</li> <li>Requires Eyes &amp; Hands</li> <li>Less Flexibility</li> </ul>	<ul style="list-style-type: none"> <li>High CapEx</li> </ul>

#### 4 CONCLUSION

The area of order picking is very interesting subject for equipment manufacturers and researchers. Many order-picking activities are today still followed by low level of used mechanization and automatization, so that in many cases order picking involves manual and

#### 4 ZAKLJUČAK

Oblast komisioniranja predstavlja interesantnu temu za proizvođače opreme, praktičare i istraživače. Danas još uvek mnoge komisione aktivnosti prati nizak nivo primenjene mehanizacije i automatizacije tako da u mnogim slučajevima komisioniranje podrazumeva

working intensive activity, which can be affected by mistakes. From all those reasons which disable full automatization of order picking process, often »traditional method« of order picking with partial automatization of certain order picking activities supplemented by modern IT provides high lever of productivity, accuracy, and is also flexible to master future demands – changes. In this paper some of the tendencies that characterize development of order picking are presented.

manuelnu i radno intezivnu ponavljajuću aktivnost podložnu greškama. Iz navedenih razloga koji onemogućavaju punu automatizaciju procesa komisioniranja često «tradicionalni metod» komisioniranja uz parcijalnu automatizaciju pojedinih komisionih aktivnosti oplemenjen savremenom IT omogućava visok nivi produktivnosti, tačnosti a takođe je i fleksibilan da savlada buduće zahteve –promene. U ovom radu istaknuti su neke od tendencija koje karakterišu razvoj komisioniranja.

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**Reviewal / Recenzija:** prof. dr Miloš Grujić